Building Adaptive Organizations: A Bridge from Basic Research to Operational Exercises*

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Abstract

Realizing the benefits of network-centric warfare—in terms of improved access to high-quality information, speed of command, and dominant application of forces—will require a synergy among three dimensions of change: *Technology*, *force organization*, and *team processes*. To achieve the potential advantages of new technological capabilities requires that we reexamine old rules of business and force-structures and recast them in ways that allow for increased flexibility and application of force where and when it is required. Experiments and exercises designed to explore alternative structures, processes, and the impacts of information technologies are complex, precisely because they force change in all three dimensions. The challenge of assessing the impacts of these changes in terms of individual, team, and overall organizational performance, are great. This paper describes an approach to dealing with the complexity of assessment described above through the application of "bridge" experiments that start with a blend of modeling and experimentation in the laboratory—to thoroughly explore core concepts and test new assessment ideas under controlled conditions—and scale to meet the challenges of

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field-level performance assessment by emphasizing those issues that proved to be performance drivers in the laboratory.

1. **Introduction**

Realizing the benefits of network-centric warfare—in terms of improved access to high-quality information, speed of command, and dominant application of forces—will require a synergy among three dimensions of change: *Technology*, *force organization*, and *team processes*. To achieve the potential advantages of new technological capabilities requires that we reexamine old rules of business and force-structures and recast them in ways that allow for increased flexibility and application of force where and when it is required. Experiments and exercises designed to explore alternative structures, processes, and the impacts of information technologies are complex, precisely because they force change in all three dimensions. The challenge of assessing the impacts of these changes in terms of individual, team, and overall organizational performance, are great.

This paper describes an approach to dealing with the complexity of assessment described above through the application of "bridge" experiments that start with a blend of modeling and experimentation in the laboratory—to thoroughly explore core concepts and test new assessment ideas under controlled conditions—and scale to meet the challenges of field-level performance assessment by emphasizing those issues that proved to be performance drivers in the laboratory. The remainder of this paper discusses an application of this approach in preparation for the Global Wargame, held at the Naval War College, in August of 1999.

2. **Bridge to Global**

Three months prior to the Global '99 Wargame, a team of warfighters, under the guidance of CCG1 and collaborating researchers from the Adaptive Architectures for Command and Control (A2C2) project sponsored by the Office of Naval Research, conducted a training exercise at the Naval Postgraduate School entitled "Bridge to Global '99." Some of the objectives met by the Bridge to Global (BTG) exercise were to provide training and exposure to alternative Joint Task Force (JTF) command and control (C2) architectures; to observe the impacts of alternate JTF C2 architectures on command processes; to explore network-centric warfare (NCW) concepts and technologies in a controlled setting; to validate and refine A2C2 organizational design methodologies in operational settings with operational experts; and to explore the capabilities of new information technology (IT21) tools as support for C2 information management and decision making.

BTG provided a low-cost, feedback-rich environment in which to explore NCW and organizational innovations with operational experts, and to collect, summarize, and feedback data and observations to maximize the training impacts and lessons learned. As a result, BTG provided reliable insights concerning the efficiency of new organizational changes and supporting technologies, many of which found their way into the Global '99 game.

Additionally, BTG provided the A2C2 research team with a forum to explore new assessment and performance measurement techniques in a rich context. Lessons learned in this area have

helped the A2C2 team scale many of their laboratory-measurement and data-analysis methods to the broader and more chaotic field setting of GLOBAL ’99.

During BTG, the A2C2 research team was able to employ a number of observational and survey data collection methods to capture qualitative and quantitative performance data. As the command staff was observed playing the simulated wargame, the observation team collected communications data, workload metrics, subjective and objective data about the tools used and the methods tried to make the best use of available technologies, and subjective data about the organizational impacts of these technologies. At the end of each day, the observation team briefed game players on the days results, and at the beginning of the next day, decisions were made about ways to change organizational processes to improve performance. The results of this process, after a week, were a number of insights and “rules of business” that were taken to Global Wargame.

2.1 *Methods Used at BTG*

The decision regarding appropriate data collection methods at BTG was a pragmatic one—the assessment team collected data that could be quickly turned around as feedback to improve the team’s communication processes and overall performance while remaining non-intrusive and requiring minimal participation by the players. Following are some of the data collection techniques used.

2.1.1 *Communication/Coordination*

To study the team’s communication patterns and ability to coordinate, two members of the assessment team used handheld computers with touch sensitive screens to record the type of information transferred from one group within the team to another. By using a Java applet program, the observers were able to collect time-stamped data of team interaction simply by tapping on a grid (see Figure 1) that specified type of information exchanged (i.e., request for information, request for action or task, request for resource utilization, request for change, transfer of information, statement about performing action or task, statement about using

TYPE & CONTENT		F/A	F/B	F/C	F/F	A/F	A/B	A/C	A/A	B/A	B/F	B/C	B/B	C/A	C/B	C/C	C/F
Requests	Information																
	Action/Task																
	Resource Utilization																
	Change																
Transfers	Information																
	Action/Task																
	Resource Utilization																
	Change																
IT21																	

Figure 1. an example of a real-time data collection grid for team communications

resources, statement about changing, and any information technology (IT21) tool use) and the source/destination dyad of that exchange (the groups within the team were called Flag (F), Alpha

(A), Bravo (B), and Charlie (C); in the grid, "F/A" signifies that the information went from the Flag cell to cell Alpha).

In addition to collecting the time-series data the data collection grid afforded, other members of the assessment team kept detailed notes about specific communications from one cell to another. These observers recorded the communications that took place when important events occurred with a special focus on those communications concerning the IT21 tools, the organizational structure, and team processes.

2.1.2 ***Teamwork Skills***

Those same observers keeping detailed notes on specific communication interchanges also noted specific teamwork behaviors such as the team's coordination behavior (e.g., what were the decision processes used to solve problems when they arise, what problems did the team encounter in solving the problem, what were the positive aspects of their coordination behavior) and IT21 tool use (e.g., what problems did they encounter and what protocol developed for the tools use). We also had the observers and each team member fill out a teamwork assessment questionnaire that measured perceived team performance in communication behavior, monitoring behavior, back-up (i.e., supporting) behavior, coordinating behavior, and team orientation (e.g., placing team goals ahead of personal goals).

2.1.3 ***Workload***

To measure workload, we used a revised version of the six item task load index (TLX) workload questionnaire that measures each team member's perceived task load in terms of mental demand, physical demand, temporal demand, performance, effort, and frustration. In the revised version, we did not measure physical demand or performance, and we gathered information for self workload, cell workload, and perceived workload for the other cells.

2.1.4 ***Situational Awareness***

To determine situation awareness (SA) we used a self report instrument for which the participants are asked to remember a specific salient event and describe what they and the other team members were doing when that event occurred.

2.2 ***BTG Results***

The above data collection techniques proved to be quite diagnostic regarding many facets of the team's performance – from the effects of diverse architectures to team information management. Some of the most relevant findings are described below.

2.2.1 *Diverse Architectures*

Before attending BTG, members of the A2C2 team used mathematical modeling to generate architectures that optimize *speed of command* – the JTF organization must meet mission objectives at maximum speed of command or op tempo, *acceptable workload* – workload should be balanced across cells, *effective team coordination* – inter-cell coordination requirements should be minimal, and *supported-supporting relationships* – the architecture should support inter-cell interaction. The optimized architectures for the two different phases of the BTG scenario are shown in figure 2. It was not surprising to find that the participants were generally pleased with both architectures, rating them high on the effectiveness of that architecture to help them complete their mission tasks, perform alternative strategies and maintain effective communications and coordination; what was surprising was the finding that these "optimal" architectures had some detrimental effects: as the organizational structure reduces the need for coordination, the individuals within that organization began to lose sight of the common operational picture (COP). It was found that regular e-briefings by each team to the entire JTF was needed to maintain global SA.

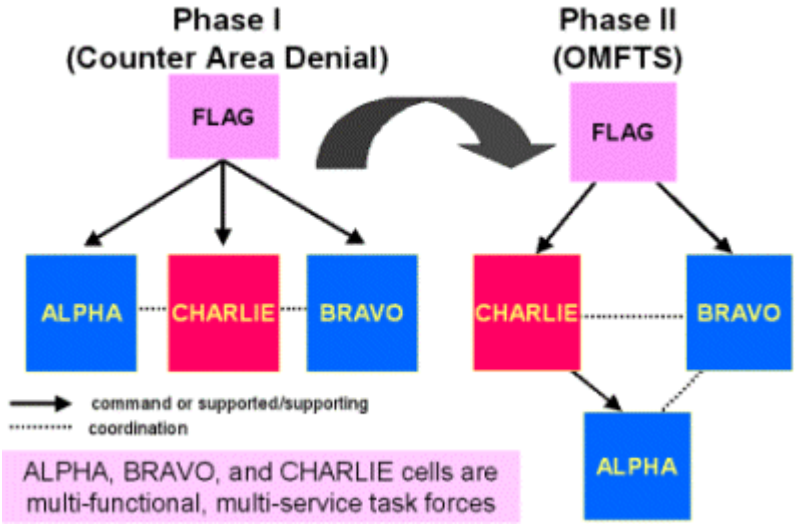

Figure 2. JTF C2 Architectures at BTG

2.2.2 *Adaptation*

As is stated in Joint Vision 2010, it is imperative that organizations be flexible enough to adapt to dynamic and diverse mission demands. During BTG the research team monitored for such adaptation – focusing on what enabled or hindered the necessary flexibility – and determined that there are a number of factors that promote adaptation when present and hinder adaptation when absent. Some of the most important enablers were the *commander's intent and clarity of roles*, *optimized C2 architecture*, and *real-time communications and shared awareness*. As long as the participants knew what was expected of them in the mission, the C2 architecture was optimized to meet mission demands, and the nodes within the team were able to communicate in real-time to keep everyone alert and responsive to the present situation, the team was able to adapt to the ever changing situation; if any of these enablers were missing the team was incapable of the flexibility necessary to be optimally effective.

From the assessment team observations, it was further concluded the presence of enablers is necessary but not sufficient to ensure successful adaptability; the team has to take a more proactive role and begin the adaptation process before it is needed. If the team waits until change is absolutely necessary it is unlikely that they will be able to adapt in a timely manner.

Understanding the precursors to adaptation is in need of further study. Although we were not able to ascertain what specific predictors of the need for change were (e.g., an abrupt change in the comm. traffic), we were able to conclude that the team needs to remain constantly aware of future likely points of failure, the appropriateness of the distribution of personnel and skills for current and future tasks, and the appropriateness of the asset/resource matches for current and future tasks.

2.2.3 ***Team Coordination and Maintaining Situation Awareness***

One requisite for effective team performance is shared situation awareness (SA). With this in mind, the participants of BTG were asked to rate a number of factors on their importance for team coordination and maintaining a shared situation awareness, and the consensus was that *real time communications* were the most important contributor for shared SA (as one of the participants wrote on the survey, "Everything else is built on comms."). Preplanning and having a common operational procedure were important also, but real time communications was consistently rated the highest.

At BTG, the only true real-time communication were the voice comms, none of the others (e.g., chat, email, whiteboard) required the constant attention that helped the participants maintain a shared SA. Other than real-time communications, some enablers of team coordination and shared SA are *tool practice*—participants needed ample opportunity to use the tools in the contest of the wargame before they could achieve the tools' full potential, *model-based architecture*—the organizational structure specially modeled to enable team coordination was a key component of the team's success, and *multiple IT21 tools*—no one tool would have been sufficient for all of the coordination and situation awareness needs. This last point is explained in more detail in the next section.

2.2.4 ***NCW IT tools***

In BTG participants were dropped into the context of a complex wargame simulation and provided with a range of digital tools for use in support of team awareness, communication, and coordination, and collaboration. At the start of BTG, the core command team was provided with very little in the way of guidelines for employment of the new tools. Instead, protocols and patterns of effective usage were allowed to evolve. Specifically, the BTG organization was given a rich set of communication and collaboration tools that included audio communications, real-time chat, email, shared whiteboard, shared map display, and videoconferencing (see Figure 3 for a screen shot of the IT21 tools used). Each of these tools was trained in isolation until team members understood the mechanics of use, but no specific guidelines were given about how the team should use the tools to do their job.

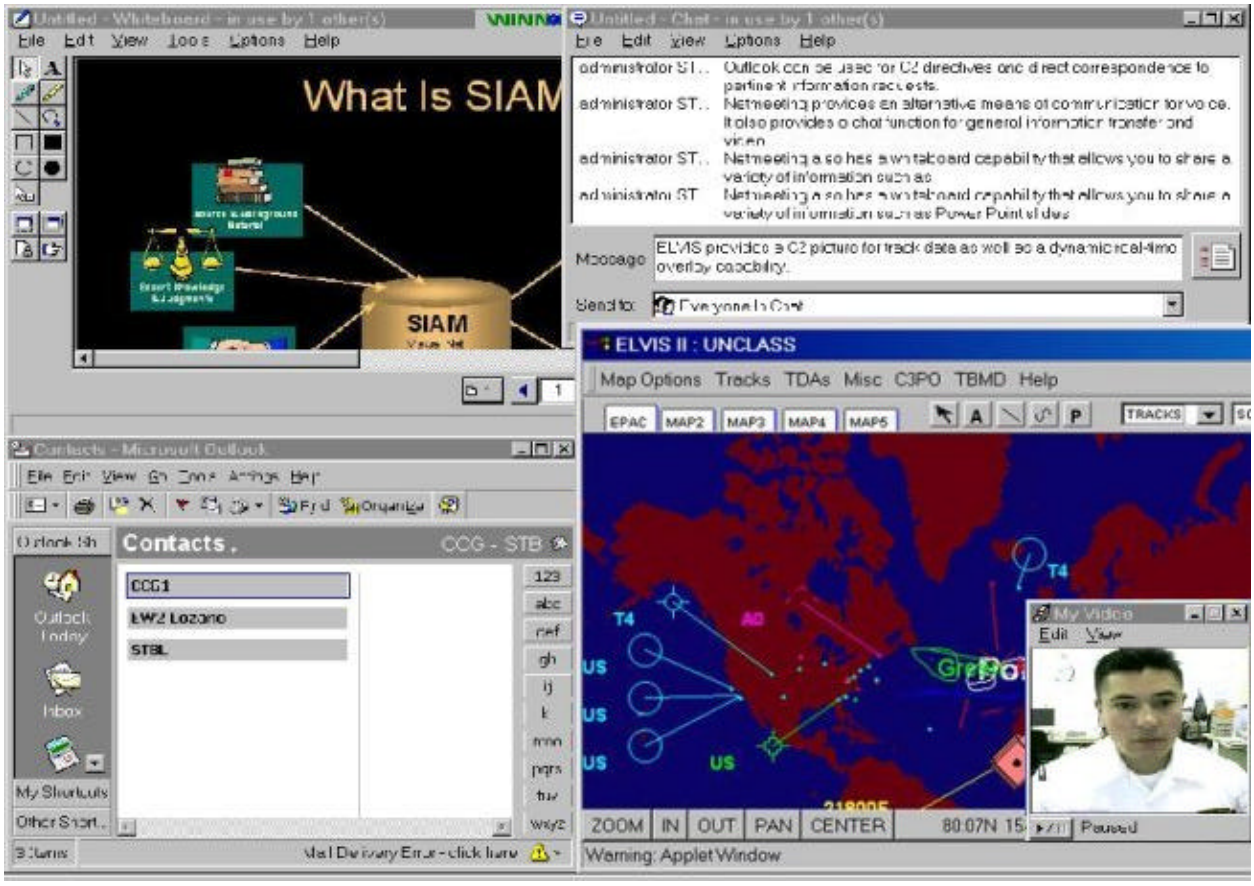

Figure 3. A screen shot of the IT21 tools.

Over the course of one week of game play, the command team evolved a number of patterns of technology use that worked very well for the small team of thirty five players, and was well suited to the dynamics of the scenarios played in the game (which were modeled after the scenarios to be played during the larger Global Wargame several months later). The emergent protocols, which can be found in Figure 4, suggest that effective communication exists only when the purpose of the communication is matched to the type of media. For example, if the communication is vital and must be attended to immediately, then the tool used must be voice comms because that is the only communication venue available that fosters such immediate attention; if a large file had to be sent as an attachment, email was used. It is important to note that the whiteboard appeared to have great potential in planning and maintaining shared SA; however, the participants were least familiar with this tool and chose to use the other, more familiar tools, instead.

Tool	Usage
Voice	**Exchanging immediate and time critical information** Real –time tactical calls Immediate actions required 'Heads up' information Coordination of tasking
Chat	**Multi-node communication** Cell to cell information exchange Cell to cell coordination Action reports to entire team (e.g., kill reports) Follow-up or backup to voice mail and e-mail
E-mail	**Exchanging information not requiring immediate response** Intel updates Requesting BDA reports Tasking
White Board	***Potential* Utility** Developing future plans Conveying the big picture

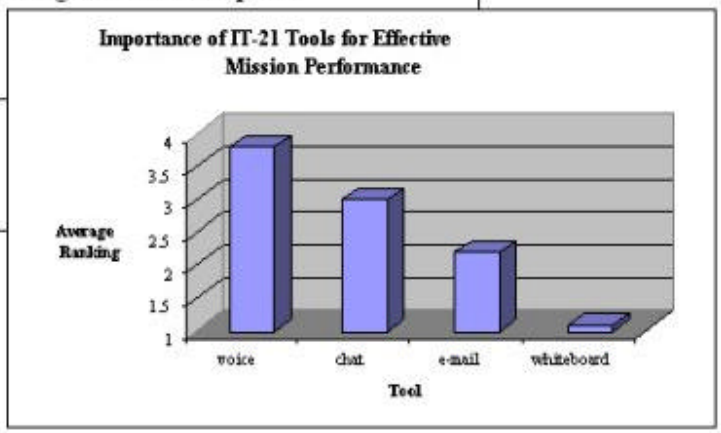

Figure 4. IT21 Tools: Evolved Protocol and Perceived Importance

3. **Crossing the Bridge to Global Wargame**

Based on the results of Bridge to Global, the A2C2 assessment team went to Global Wargame '99 with custom tailored measures and a focus inspired by our experimental findings. We tailored our data collection and assessment efforts to capture impacts of information technologies and collaborative tools (e.g. chat, shared COP) on team process and performance, and looked closely at efforts made by the JTF and its subordinate cells to leverage these tools to accomplish improved speed of command through an Effects-Based approach to Command and Control (C2).

3.1 ***Methods Used at Global***

To provide adequate assessment coverage, a handful of raters from the A2C2 assessment team attended GLOBAL '99 where they used very similar collection techniques as those used for BTG to gather information on teamwork skills, workload, and situational awareness; however, because there were so many more players spread out over a much larger area, the data collection technique for Communication/Coordination had to be revised. Instead of relying on the handheld computers to capture every information transaction, each member of the assessment team was equipped with rating manuals specifically designed to capture interactions between team members, team coordination behaviors, adaptations of the team architecture over time, changes in command structure, and uses of IT21 tools (see Figure 5 for examples of pages from the raters' manuals). Each rater—standing in one of the following seven areas: Current

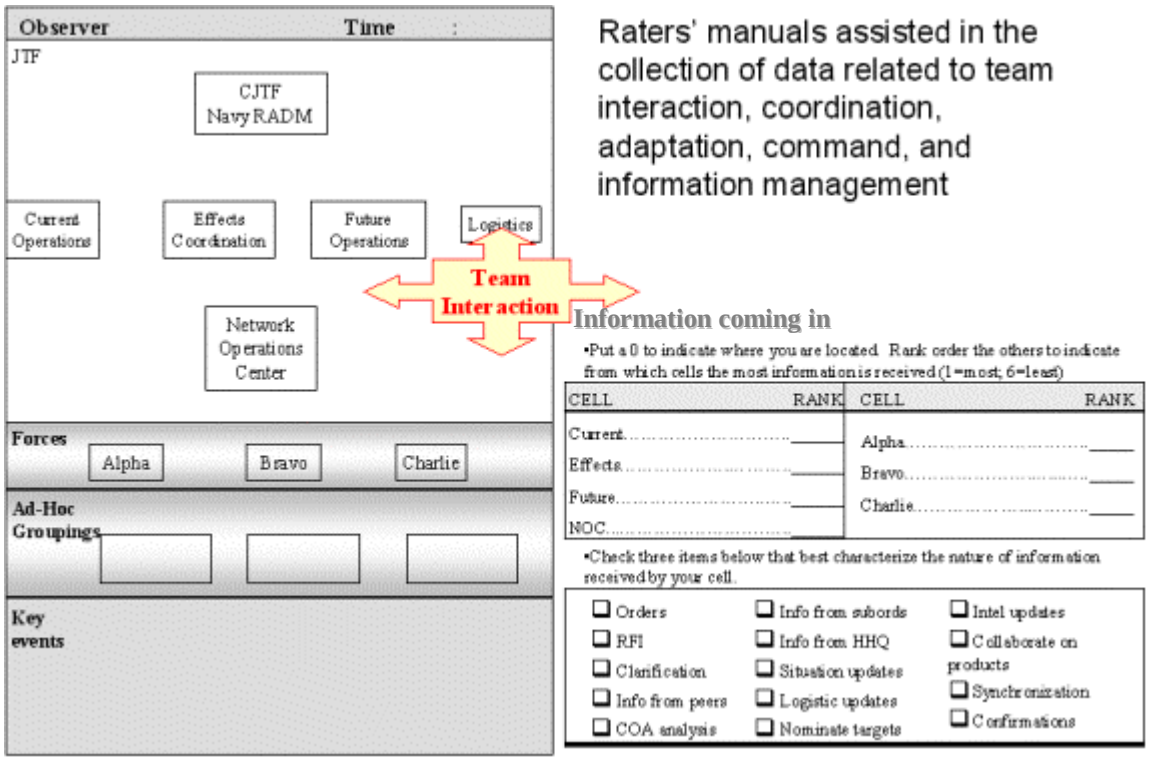

Figure 5. Rating Communication and Coordination in Global

Operations, Future Operations, Effects Coordination Board, Network Operations Center, Subordinate Joint Task Force (SJTF) A, SJTF B, SJTF C—compiled extensive observations on the team interactions.

3.2 ***Lessons Learned***

Four broad themes, or lessons learned, emerged from our observations, and these will be used to provide a framework to organize this final discussion. These themes were:

- *The importance of training*—While the BTG was a research experience for the A2C2 team, it was a valuable training experience for the command staff. Without adequate, in-context training, it is not possible for an organization to realize the promises of new technologies.

- *New tools require new rules*—Just as there are certain kinds of meetings that just have to be done face to face, there are certain kinds of messages that are better sent as email than as a chat message. Discovering, codifying, and adhering to rules and heuristics for tools use can make it much easier for an organization to take advantage of these tools.

- *The myth of "global situation awareness"*—The global availability of information can create an illusion that everyone knows what you know, and lead to errors of omission or false expectations. It is important that tools, plans, and other organizational methods be used to insure that team members develop adequate understanding of one another roles, information purview and information requirements.

- *Knowledge management may be a distinct organizational role*—Particularly when the size of an organization gets large (as in the Global Wargame) the job of managing all potential sources of information, and making sure decision makers have access to what they need when they need it, requires special expertise. It is increasingly recognized that the role of "knowledge manager" is an important new organizational role.

In the paragraphs that follow, we discuss these themes in greater depth, using examples from BTG and Global wargame.

3.2.1 ***The Importance of Training***

Changes in the availability of information and abilities of individuals to share what they know across traditional boundaries alter organizational dynamics in a number of ways (Prestridge, Hansen, Sessa, & Kossler, 1999). To be successful, technological change must be accompanied by other changes such as training, structural changes in the organization, and changes in the processes and rules of business communication (Offermann & Eller, 1999; MacMillan, Paley, Levchuk, & Serfaty, 1999).

The transition from BTG—where players were afforded individualized tool training with ample feedback—to Global Wargame—where many of the players were exposed to network-based communication and collaboration tools for the first time—made one thing very clear: Quality digital skills training, embedded in the context in which the tools will ultimately be used, is a crucial determinant of an organization's success in practice. While it is not surprising to say that training and practice lead to improved performance, the point goes deeper than that. What BTG provided was more than an opportunity to work hands-on with the tools: It additionally provided players with a cost-free, feedback rich, environment in which to explore different ways that the tools might be used to practice C2.

There were two distinct types of training that took place at BTG. The first was what is often called "buttonology" training, or training in the mechanics of tool use. The second, and arguably more important, type of training was the in-context training, where new tools were truly tested and experienced in the context of job performance. In the transition from BTG to Global Wargame, the assessment team was afforded a glimpse at the ramifications of providing one type of training without the other.

At BTG, players received hands-on buttonology training early in the week, to familiarize them with the mechanics of the tools, their capabilities, and a few suggestions about how they might be employed. Players started chat groups, joined and left them, set up email addresses, tested their video connections, and interacted with the white board and shared map displays. After they were familiar with the tools, the simulation game started, and players were faced with the task of figuring out how to use all of these new capabilities to help them work. This "free-form" phase was training in the sense that, though they were left to their own sense of how to proceed, the observation team was present to collect data on their progress and choices, and summarized this material as structured feedback and a framework for self reflection. This provided the command staff the ability to chart their own progress with the tools and actively participate in the

development of rules of conduct and best practice for tool use. The products of this effort are discussed in the following section.

When the BTG group went to Global Wargame, they were some of the only players who had been afforded opportunities to work with new technologies in the context of their work, and it showed. As is too often the case, the Global Wargame developers scheduled time for tool training early in the week, but focused exclusively on butonology, with no time for structured, in-context tool training. As you might expect, four hundred people, sharing time on fewer than four hundred computer screens, in an attempt to learn how to use an arsenal of new tools to help them do their job, was less than perfectly effective. As the game designers quickly learned, valuable game time ended up being used as training time, during which players really educated themselves about the ways new technologies can be used to help them conduct C2.

As will become evident in the following sections, the training required to blend new technologies with changes in organizational structure and organizational processes only happens when the buttonology is over and the organization puts new technologies to the test, in context. A major lesson learned from the BTG and Global Wargame experience is that in-context tool use, coupled with data collection, structured feedback, and ample self reflection are required to develop, agree to, and codify organizational rules of practice that allow team members to fearlessly utilize new tools in ways that they are confident will be consistent with their teammates understanding of the models of communication and collaboration adopted by the organization. These rules of practice derived in the context of C2 have already been discussed and are further detailed in the next section.

3.2.2 *New Tools Require New Rules*

Just as there are certain kinds of meetings that just have to be done face to face, there are certain kinds of messages that are better sent as email than as a chat message. Discovering, codifying, and adhering to rules and heuristics for tools use can make it much easier for an organization to take advantage of these tools.

A primary finding from our exploratory research has been that the proliferation of new communication and coordination supporting tools requires a brand new set of rules, protocols, and guidelines-for-use to help teams understand when and how best to use them. Each of the tools mentioned differs in the time they take to employ, the delays associated with message delivery, bandwidth requirements, and invasiveness (to name a few).

To be used effectively, the team required a rudimentary set of guidelines for how to utilize their new tools to get the job done. Over the course of four days of mission practice, the team developed a simple protocol (outlined in figure 3) in which email was restricted to cases in which the message to be sent had multiple recipients and an attached file such as a map or target list. Chat sessions turned out to be key as a means of providing a running record of organizational activities, and this tool evolved into a multipurpose communication channel that kept the radios free for other varieties of communication. Video turned out to be too much trouble in the heat of battle, but it was suggested that this technology will be crucial in planning. The whiteboard was rarely used even though a number of players recognized the potential usefulness of such a tool—

they cited their unfamiliarity with the tool as being an insurmountable obstacle to its use in the fast paced wargame (again, this simply re-emphasizes the need for proper training in tool use and protocol). These protocols were further tested and refined several months later in the larger Global '99 wargame.

While many organizations have long histories of audio communications as a primary means of coordinating distributed team members, the protocols and methods that have grown up around the radio are not always the best fit for collaboration supported by new, network-based tools. With continued use, new rules are evolving for email, chat, videoconferencing, shared graphics spaces (i.e. whiteboards and common map displays) and other network communication tools.

3.2.3 *The myth of "global situation awareness"*

The ability to stay informed, and up-to-date is a promise that has long been associated with network-based computer services, particularly with the advent of the internet and associated technologies such as personalization and information push. In military C2 contexts, this promise is often exaggerated still further to suggest that every person will have access to all possible information, and will therefore be constantly "situationally aware." This myth can be hazardous for several reasons: It can lead the belief that others know things that they do not and thus cause individuals to develop expectations about behaviors that won't happen, it can cause individuals to push unintelligible data to others, or it can lead to omissions on the assumption that information available to one is available to all and therefore not worth sending. Regardless of the outcome, the myth of global situation awareness can impact the ability of the organization to stay informed, coordinate activities, and manage information.

The A2C2 team observed several interesting themes related to the myth of global awareness, but two stand out as particularly relevant in the context of organizational change: The importance of information management skills and training, and the multi-source nature of what the military refers to as the "common operating picture." These will be discussed in turn.

<u>Information management and organizational knowledge</u>
Understanding how to manage information in an organizational context requires more than a passing familiarity with the "cc" function in an email client. Managing information well requires information filtering, fusion, push, and pull, all informed by knowledge of organizational roles and shared goals. As can be seen in Figure 4, some of the most troublesome barriers to proper information access has to do with not knowing where to get information and inadequate responses to information requests. With proper training and

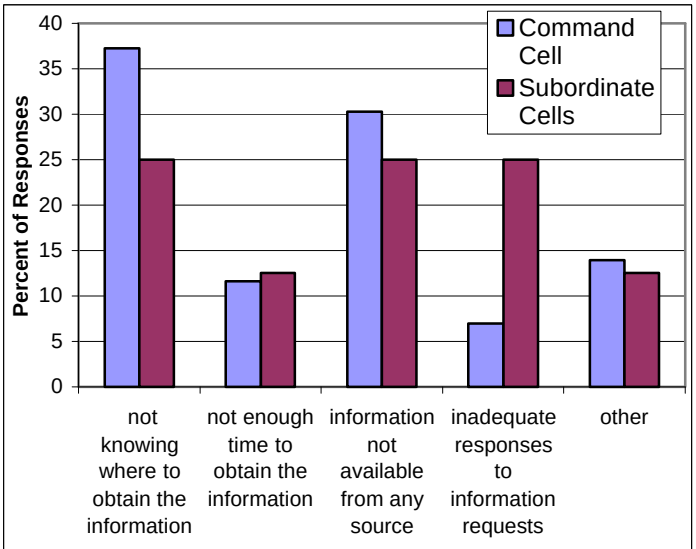

Figure 6. Barriers to Information Access

organizational knowledge, these two barriers can be overcome.

Information Overload and the Common Operating Picture One of the key findings of our research was that, with the increasing number of information sources available in the modern work environment, no one tool can any longer be counted on as the single source for keeping the team up-to-date and coordinated. The military concept of a "common operating picture" may not be a picture in the graphic sense at all, in fact. Rather, the common operating picture is a sense of shared awareness fostered by the collection of globally available information sources and tools.

3.2.4 *Knowledge management may be a distinct organizational role*

Particularly when the size of an organization gets large (as in the Global Wargame) the job of managing all potential sources of information, and making sure decision makers have access to what they need when they need it, requires special expertise. It is increasingly recognized that the role of "knowledge manager" is an important new organizational role. Because of this, the assessment team decided that it may be necessary to dedicate an individual or team of people as knowledge managers whose sole job it is to monitor multiple information sources, interpret and disseminate data and information in support of the team. In the context of the military wargame a new cell, the Network Operations Center (NOC), was developed to look at communication traffic patterns and flow in the IT21 tools to optimize "smart push – smart pull" to make sure the players are not looking at old information.

The NOC was implemented in Global '99 but was not a successful knowledge manager; instead, a couple of players who were extremely knowledgeable about both the job that needed to be done, as well as the information networking operations being used, rose to the occasion and filled the knowledge management void. It appears as though just knowing the information flow and traffic patterns is not enough to guarantee knowledge management, a solid understanding of the job—or the context in which the knowledge is to be used—is needed for proper information management. Next year, for Global '00, one person in every cell will be thoroughly trained in both the job that the cell is responsible for as well as in the information technology being used. This person will be the knowledge manager for their particular cell. Similar positions would be of use in nonmilitary organizations to make sure organizational members are kept up-to-date with information relevant for their organizational position. This person must be more than a systems administrator who, like the NOC, would know the information network but not the specific jobs; this person must be thoroughly knowledgeable of the job if s/he is to successfully manage the knowledge.

One further interpretation of the above findings—that the knowledge managers rose not from the network administrators whose job it is to oversee all information flow, but from players who just happened to have access to all the information because of the omnipresent information flow—is that network communications tools can flatten an otherwise hierarchical organization by providing a conduit for rapid information dissemination anywhere in the team. Thus, we found that collaborative tools can have impacts at the organizational level in ways that radio never had.

4. **Conclusion**

Building adaptive organizations is proving to be quite a challenge, requiring simultaneous improvements among the three dimensions of organizational structure, team process, and information technology. The experiments and studies designed to explore changes in these three dimensions are quite complex, and span the entire experimental research design arena from basic research to laboratory experiments to field research practiced in wargames such as Global '99. Studies that test the models developed in basic research in such a way that the models can be improved upon and scaled up for larger wargames are essential if we are to successfully implement new concepts along all three dimensions—BTG proved to be such a study. Not only did BTG allow for more control than is possible in the operational exercises—allowing the participants to get much needed practice and feedback, but it provided more realistic situations than the usual lab experiment—allowing for the testing of hypotheses, theories, and models in a more realistic setting, and it shortened tool familiarization time at Global so the assessment team could test and adapt NCW architectures—which requires that the participants already be trained in them. "Lesson's learned" from BTG and Global are discussed in this paper and are intended to recount the findings from BTG and Global, and serve as initial guidelines to help researchers determine how to realize the full benefits of NCW.

5. **References**

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